PATENT SPECIFICATION

Application Date: Oct. 18, 1938. No. 30085/38.

521,548

Complete Specification Left: Aug. 16, 1939.

Complete Specification Accepted: May 24, 1940.

PROVISIONAL SPECIFICATION

Improvements in Tubular Heat Exchange Apparatus

I, EDWARD FRANK SPANNER, of 13, Shooters Hill Road, Blackheath, London, S.E.3, British, do hereby declare the nature of this invention to be as follows:—

This invention is concerned with tubular heat exchange apparatus in which heat transfer is required between hot and cold fluids, and particularly with boiler or waterheater smoke tubes or firetubes through which hot gases are passed from the furnaces of direct-fired boilers, or from other sources of hot gases such as the exhaust gas from gas engines or Diesel engines, and has for its object in such cases improvement of the rate of heat transfer from the hot gases within the tubes to water surrounding these tubes.

The invention is carried into effect by providing one or more plain, stepped, or tapered spiral grooves along the whole or part of the length of each tube, the spiral grooves being formed by pressing the wall of the tube inwards towards the axis of the tube. These inwardly pressed grooves force the gas to take a partially spiral path in passing from one end of the tube to the other and also to come into more intimate contact with the wall of the tube wherever the stream of gas is forced by its speed of flow across the line of the inwardly pressed groove. An additional beneficial effect is secured when the grooves are deepened in a stepped or tapered manner and/or modified in angle and direction of pitch towards the exit end of the tube, by reason of the fact that the available area of the passage through the tube is gradually restricted, thereby causing the speed of flow of the gas to be maintained or even accelerated although the volume of the gas is reduced due to its loss of temperature.

Where desired, the invention also provides for the inclusion within the tube of a plain or twisted strip of metal to serve as an additional agent for promoting turbulence in the gas flow, and also to afford support to the tube from the inside when it is subjected to external water pressure.

It should be noted that in addition to the cases already mentioned the invention is also of value in gas fired boilers having an individual jet to each tube.

The great advantage of the invention is that a given heat transfer can be secured with shorter tubes and therefore a shorter and lighter boiler or heat exchange unit. Further, the rate of heat transfer per square foot of tube surface is brought nearer to a constant figure from one end of the tube to the other, thus improving the technical efficiency.

Dated this Seventeenth day of October, 1938.

E. F. SPANNER.

COMPLETE SPECIFICATION

Improvements in Tubular Heat Exchange Apparatus

I, EDWARD FRANK SPANNER, of 13, Shooters Hill Road, Blackheath, London, S.E.3, British, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention is concerned with tubular heat exchange apparatus in which heat transfer is required between hot and cold fluids, and in which the hot fluid i.e. gas or liquid is passed from an inlet chamber to an outlet chamber through a multiplicity of straight tubes expanded into tube plates at the ends of a shell containing or confining the cold fluid i.e. gas or liquid, to which heat is to be transferred.

Efficiency of heat transfer is dependent upon bringing all parts of the hot stream of fluid passing through each individual tube into intimate contact with the wall of that tube, and in preventing "coring" of the hot fluid i.e. passage of a central core of hot fluid along the tube, from the wall of which it is separated by outer layers of cooler fluid. Such coring is par-

ticularly disadvantageous to efficiency in heat transfer when the hot fluid is a gas.

In apparatus of normal practice using plain round straight tubes, there is a short portion of tube near the inlet end, of length from about 4 times to about 6 times the internal diameter, along which the rate of heat transfer is high by reason of the turbulence which exists in this region as the result of the fluid having suddenly been accelerated in a confused manner while entering the tube.

This turbulence does not persist beyond this distance and the present invention artificially reinstates and accentuates this condition of turbulence before coring can commence, by providing that each tube according to this invention shall have pressed into it two or more grooves, these grooves starting from a point a distance of from about 4 times to about 6 times the internal diameter from the inlet end of the tube, and being carried along the tube in a spiral form to a point within two to three diameters of the outlet end.

When the hot fluid being dealt with is a gas the invention does more than simply accentuate turbulence. It is well known that gas contracts very rapidly with reduction in temperature. Also that exchange of heat between a hot gas flowing along a tube, and the wall of that tube, is adversely affected by a falling off of the linear velocity of the gas relative to the wall surface.

The present invention secures that the linear velocity of flow of the gas relative to the wall of the tube shall be prevented from falling off, although the gas is being cooled and reduced in volume as it passes along the length of the tube from inlet to exit, by providing that the depth of the spiral grooves shall be increased from the inlet towards the outer ends, either in a series of steps, or as a gradual taper; or that the number of turns of the spirals per unit length of the tube shall become greater towards the outlet end of the tube than it is at the inlet end; or that both of these devices shall be used together for the purpose of securing the objects already set forth. The invention also provides that in order further to increase the degree of turbulence promoted in the flow of the hot fluid, the direction of rotation of the spiral grooves may be changed along the length of the tube, if desired, and that, for simplicity of manufacture, the spiral grooves may be interrupted—that is made in short lengths.

It is very important that the depth and pitch of the spiral grooves should be carefully chosen in order that (a) there shall be no undue increase in the amount of resistance offered to the passage of the gas through the tubes such as would occur with two deep grooves of too small a pitch, (b) that there shall be no undue reduction of strength of the tube against external pressure such as would occur with grooves of too large a pitch, and (c) that it should be a simple and straight-forward matter thoroughly to wire brush the inside of the tube using spiralled brushes of ordinary commercial standards. The invention secures that these several requirements shall be satisfied by providing that the maximum depth of the grooves shall not exceed about $\frac{1}{8}$th the external diameter of the tube, and that the pitch of the grooves should be between 6 and 8 times the internal tube diameter.

Where there is a very high temperature at the inlet end of the tube and consequently a very considerable change in density of the gas between inlet and outlet, the invention provides that a plain strip of metal or one twisted in the opposite direction to the spiral grooves may be introduced along the length of the tube for the purpose of conducting some of the heat from the inlet end of the tube towards the outlet end where the heat may again be given back to the hot gas and then be transferred to the tube wall; such a strip of metal also serves the purpose of increasing turbulence by stopping any tendency for the gas to take on a simple spiral motion.

Finally, since, in the case of hot gas, the effect of these devices falls off somewhat with slowing down of the linear velocity of gas flow, the invention provides that, when desired, the number and size of the tubes chosen shall be such that the linear velocity of gas flow along the tube at its entrance shall be not less than 60 feet per second.

The invention applies to all kinds of heat transfer apparatus, in which hot gases or liquids pass through tubes surrounded by cold gases or liquids and equally to cases in which cold gases or liquids pass through tubes surrounded by hot gases or liquids It is immaterial also from what sources the supplies of hot gas or liquid are obtained, or whether the hot gases are produced by combustion taking place within the tube itself at the inlet end.

Referring to the attached drawings, Figure 1 shows an outside view of a tube according to this invention, in which A is the tube, and CCC are the grooves.

Figure 2 shows a cross section across the tube shown in Figure 1 on the line *aa*.

Figure 3 shows an outside view of a tube A according to this invention, in which the grooves get deeper along the length of the tube, the groove at F being deeper

than the groove at E and the groove at E deeper than the groov at D.

Sections of the tube at *aa* and *bb* are shown in Figure 4 and Figure 5 respectively.

Figure 6 shows the outside of a tube A according to this invention in which the distance between the grooves GG towards the entrance to the tube is greater than the distance between the similar grooves HH towards the end of the tube.

Figure 7 shows a tube A in accordance with the invention in which the direction of rotation of the spiral groove changes along its length.

Figure 8 shows a tube A according to this invention in which the spiral grooves L are interrupted i.e. made in short lengths.

Figure 9 shows a longitudinal cross section through a tube A according to the invention provided with grooves CC, and having along its length, within the tube, a twisted element M.

A cross section of this tube along the line *aa* is shown in Figure 10.

In all these drawings it will be understood that the number of grooves provided in the tube may be two or more.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. A straight tube for use in heat exchange apparatus having at the inlet end a plain length of tube of from about 4 times to 6 times the internal diameter of the tube followed by a length of tube having two or more spiral grooves inwardly pressed into it and continuing along its length to a point within 2 to 3 diameters of the outlet end.

2. A straight tube as claimed in Claim 1 in which the spiral grooves are increased in depth ither gradually or in a series of steps towards the outlet end of the tube.

3. A straight tube as claimed in Claim 1 in which spiral grooves are decreased in pitch either gradually or in steps towards the outlet end of the tube.

4. A straight tube as claimed in Claims 1, 2 or 3 in which the direction of rotation of the spiral grooves is changed along the length of the tube.

5. A straight tube as claimed in Claims 1, 2, 3 or 4 in which the spiral grooves are interrupted, that is made in short lengths.

6. A straight tube as claimed in Claims 1, 2, 3, 4, or 5 in which the maximum depth of the grooves does not exceed about one-eighth the external tube diameter.

7. A straight tube as claimed in Claims 1, 2, 3, 4, 5 or 6 in which the pitch of the spirals lies between about 6 and 8 times the internal diameter of the tube.

8. A straight tube as claimed in Claims 1, 2, 3, 4, 5, 6 or 7, in which a plain or contrary-twisted strip of metal is introduced within the tube running along its length.

9. Straight tubes as claimed in Claims 1, 2, 3, 4, 5, 6, 7 or 8, so chosen in number and size, in relation to the stream of gas to be dealt with, that the linear velocity of gas flow along the tubes at the entrance is not less than 60 feet per second.

10. Straight tubes, having inwardly pressed grooves, and internal metal strips, and such that the gas velocities therethrough are as claimed in Claims 1 to 9 inclusive, and as described and illustrated in the accompanying drawings.

Dated this 16th day of August, 1939.

E. F. SPANNER.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1940.

[This Drawing is a reproduction of the Original on a reduced scale.]

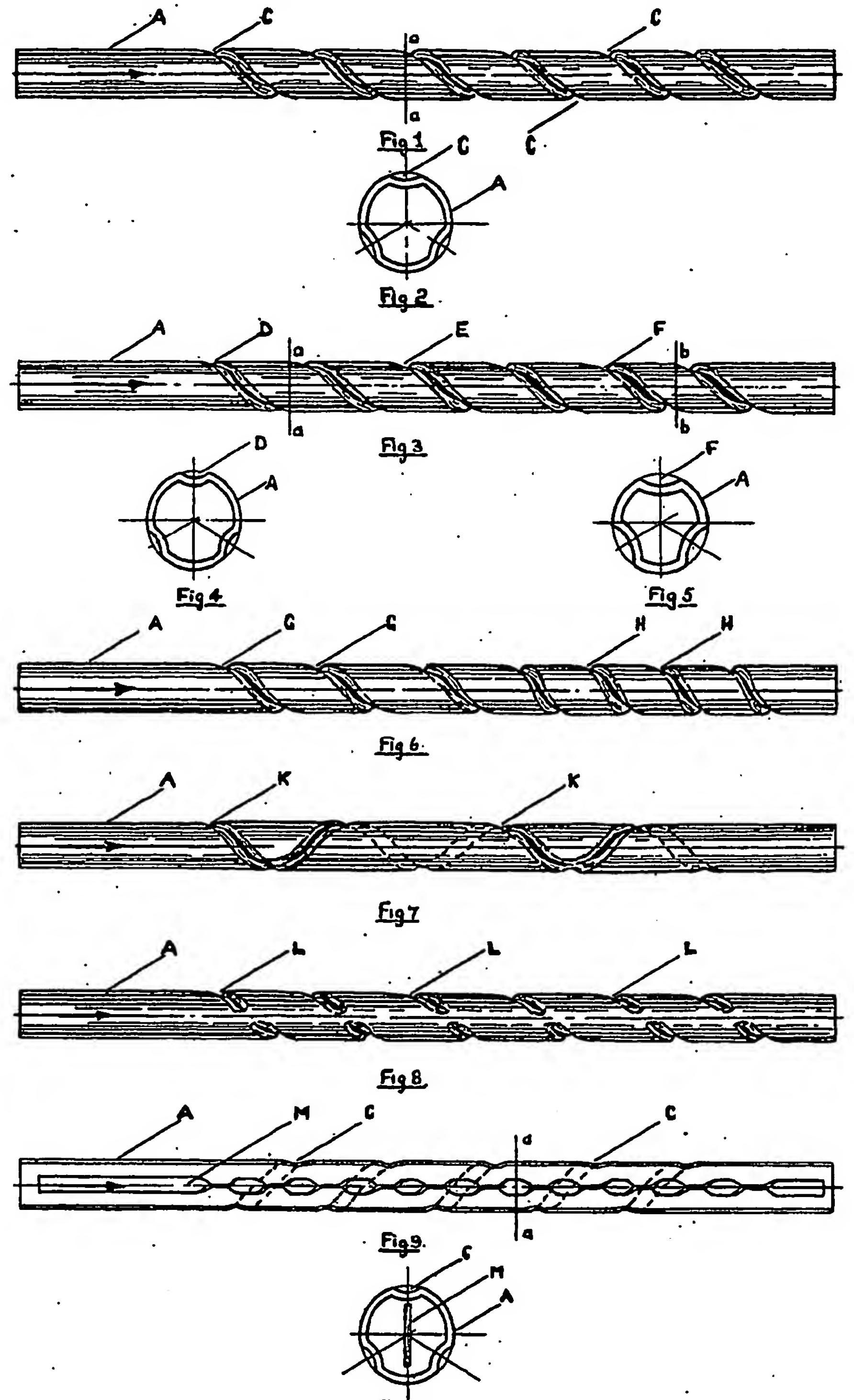

Fig 1 Fig 2 Fig 3 Fig 4 Fig 5 Fig 6 Fig 7 Fig 8 Fig 9 Fig 10